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(54) Monitoring of elevator door performance

Überwachung von Aufzugstürleistung

Surveillance de la performance d'une porte d'ascenseur

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(56) References cited:
- **PATENT ABSTRACTS OF JAPAN vol. 018, no. 487 (M-1671), 12 September 1994 & JP 06 156902 A (HITACHI BUILDING SYST ENG & SERVICE CO LTD), 3 June 1994,**

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Description

[0001] The present invention relates to elevator door monitoring and, more particularly, providing elevator door performance data.

[0002] Any number of systems operating at a plurality of remote sites may be monitored using sensors at the remote sites and transmitting information on the present status of a number of parameters during the systems' operation at the sites, such as an elevator door system in a plurality of remote buildings. In conventional remote monitoring systems, the parameters are analyzed by a signal processor so as to determine if any parameters have changed state. If so, the present value of the changed parameter is plugged into a Boolean expression defining an alarm condition in order to determine if the Boolean expression is satisfied and hence the alarm condition is present. If so, an alarm condition is transmitted and displayed as an alarm message. Each data point of each parameter is transmitted independently of other data points and a fixed threshold is used to indicate the presence of an alarm. This approach focuses on alarm data and provides little information concerning performance degradation. Thus, this approach makes it difficult to determine or detect degradation of door performance over a period of time.

[0003] An additional difficulty is presented by the large number of different parameters which need to be analyzed resulting from the large number of available elevator door operating systems. Conventional remote monitoring systems are not well equipped to handle the large variety in the parameters to be monitored. A remote monitoring system is known for example in JP-A-06156902.

[0004] Consequently, a system and a method for monitoring these elevator door systems that avoids the above-mentioned drawbacks is clearly desirable.

[0005] It is an object of the present invention to provide an apparatus and method which provides an improved method of monitoring an elevator door system.

[0006] It is a further object of the present invention to provide an apparatus and method which monitors elevator door performance in addition to monitoring alarm conditions caused by elevator door faults.

[0007] It is another object of the present invention to provide an apparatus and method for monitoring a plurality of different elevator door systems having a plurality of parameter signals to be monitored.

[0008] In accordance with the present invention, an apparatus provides an elevator door performance result of an elevator door in an elevator door system. The elevator door system normally operates sequentially from state-to-state in a closed loop sequential chain of normal operating states. The apparatus monitors a plurality of parameter signals provided by the elevator door system. The apparatus comprises a door state sequencer for providing a performance measure in response to a plurality of parameter signals provided by the elevator door system; a module for providing a reference measure and an acceptable range for the door performance measure in response to the sequential chain of normal door operating states; and an abnormal detection module for analyzing the door performance measure such that if the door performance measure is within the acceptable range a performance result is provided by averaging the performance measure with the reference measure.

[0009] In further accordance with the present invention, a method for providing an elevator door performance result of an elevator door in an elevator system comprises the steps of: determining a reference measure for the elevator door; determining an acceptable range for a performance measure in response to the reference measure; providing the performance measure from a door state machine which monitors a plurality of parameter signals provided by the elevator door system, the door state machine following a sequence of elevator door operations; determining if the performance measure is within the acceptable range; and providing a performance result by averaging the performance measure with the reference measure if the performance measure is within the acceptable range.

[0010] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is an illustration of an elevator monitoring system;

Fig. 2 is a simplified block diagram of a door diagnostic logic according to the present invention;

Fig. 3 is an illustration of a state machine model for a first class of elevator door systems, according to the present invention, of an elevator door system which normally operates from state-to-state in a closed loop sequential chain of normal operating states;

Fig. 4 is an illustration of a state machine model for a second class of elevator door systems, according to the present invention, of an elevator door system which normally operates from state-to-state in a closed loop sequential chain of normal operating states; and

Fig. 5 is an illustration of a state machine model for a third class of elevator door systems, according to the present invention, of an elevator door system which normally operates from state-to-state in a closed loop sequential chain of normal operating states.

REMOTE MONITORING SYSTEM

[0011] Figure 1 illustrates the present remote elevator monitoring system 10 for monitoring individual elevators in remotely located buildings 12, for transmitting alarm and performance information to associated local monitoring centers 14. The method of communication between the remote buildings and the various local offices is a bi-directional communication system whereby inoperative elevators are identified and individual elevator door performance information is transferred to a local monitoring center through the use of local telephone lines which may include radio frequency transmission paths. It should be understood that although the remote elevator monitoring system disclosed herein utilizes the public switch telephone network available within the local community in which a particular local monitoring center and its associated remote buildings are located, other equivalent forms of communication may be utilized. For example, other communication systems such as an Internet or Intranet communication system may be used with the present invention.

[0012] Each remote building of the remote elevator monitoring system includes a main 18 and one or more subordinates 20. The individual subordinates 20 are directly attached to sensors associated with an associated elevator and elevator door. The subordinates 20 transmit signals indicative of the status of selected parameters via a communication line 22 which comprises a pair of wires. The use of a two wire communications line between the main 18 and its associated subordinates 20 provides both an inexpensive means of data transmission and the ability to inexpensively dispose the main in a location remote from the subordinates. For instance, if all of the subordinates are located in the elevator machine room having a hostile environment on top of an elevator shaft, the main may be inexpensively located in a more benign environment in the building. Although the architecture of the remote elevator monitoring system within a remote building has been described as having a main communicating with one or more subordinates using an efficient two-wire communication line, it should be understood by those skilled in the art that other means of data communication and transmission including less efficient means may also be used. It should also be understood that because the number of subordinates capable of being attached to a given communication line is finite, it may be necessary within a given remote building to utilize more than one main-subordinate group.

[0013] Each main 18 includes a microprocessor which evaluates the performance data and determines whether an alarm condition exists according to a state machine model which is coded within the software of the microprocessor. The microprocessor through signal processors conditions the inputs provided by each subordinate 20. These inputs are then used by a state machine to determine the status of the doors as is explained herein below. As a result of the direct connection of the subordinates to the sensors, the state machine is directly responsive to the actual devices that are being monitored. Thus, any errors which may be introduced by an elevator controller are avoided. This is an advantage over conventional remote monitoring systems which are indirectly responsive to the sensors via elevator controller inputs. As the inputs are processed by the microprocessor various events and conditions are recorded and stored in the memory.

[0014] In one embodiment, each subordinate also includes a microprocessor which evaluates the performance data and determines whether an alarm condition exists according to a state machine model which is coded within the software of the microprocessor.

[0015] Each of the remote buildings 12 communicates with its associated local monitoring center 14 to provide an alarm and the performance data. More specifically, each main 18 communicates with a modem 24 which transmits alarm and performance data to a modem 26 in the associated local monitoring center 14. The local processor 28 stores the retrieved data internally and alerts local personnel as to the existence of an alarm condition and performance data useful for determining the cause of the alarm. The local processor 28 alerts local personnel of these conditions via printer 30. It should be understood that other means of communicating with local personnel, such as a CRT may also or alternatively as easily be used. Each local processor 28 may transmit alarm and performance data via the modem 26 to another modem 32 located in a data storage unit 40. The alarm and performance data may then be stored in a database 34 for long term evaluation. Although bulk data storage is a desirable feature of the present invention, it should be understood that bulk data storage for the purpose of long term performance evaluation is not absolutely essential for the practice of the present invention. Of course, it should be recognized by those skilled in the art that the present invention may be used in a variety of monitoring systems.

DOOR DIAGNOSTIC LOGIC

[0016] Referring to Fig. 2, a door diagnostic logic is implemented in each main 18. Alternatively, the door diagnostic is implemented in the main 18 and each subordinate 20. The function of the door diagnostic logic is to capture and store door diagnostic data. Accordingly, the door diagnostic logic requires access to a number of door signals as well as other existing remote elevator monitoring signals as is described below. Off-site data analysis algorithms are used to capture data to perform door diagnostics. The door diagnostic logic is separated into three modules; namely, an initialization logic, an abnormality detection logic and a door state machine.

[0017] The initialization logic is designed to set the initial conditions and is implemented as the remote elevator monitoring system is started in order to provide a statistically robust reference data set for use in the abnormality detection logic.

[0018] The abnormality detection logic is designed to maintain statistically valid mean and standard deviation values for specific intervals within the door system. The logic uses the previous mean and standard deviation and the state machine to qualify a new data point that is processed by the state machine for a door. If the data point is determined to be normal, that data point is used to update the current mean and standard deviation calculations.

[0019] The door state machine is a sequence model of the door system. Accordingly, the door state machine is also defined as a door state sequencer. The door state machine models the different states of door operation. Each state is a result of the previous state and a given condition (i.e. change of an input) which was achieved. The selection of the correct sequences for each door system is based on the available door signals. There are three classes of automatic door systems that are monitored, each of which have different door signals. Thus, the required signals are different for each door state machine and each class of door system is modelled by a different state machine based on the signals available at the door system. The three classes of door types are:

1) Automatic doors with door open and door close command. This class of door system has four signals available for monitoring; door open command, door close command, door open limit and door switch.

2) Automatic doors with door open command. This class of door system has three signals available for monitoring; door open command, door open limit and door switch.

3) Simple automatic doors - This class of door system has only two signals available for monitoring; namely, the door open command and the door switch.

[0020] The output of the door diagnostic logic is bins of data. The performance data includes:

- Interval means
- Interval standard deviations
- Specific state counts
- Abnormality counts
- Normal Interval Counts per Performance Data Update
- Out of sequence counts

[0021] The door diagnostic logic also outputs door status:

- Door Commanded Open
- Door Opening
- Door Open
- Door Closing
- Door Closed

[0022] The door state machine comprises nodes and vectors. A node is the resultant status of the door due to a sequence of events that have occurred on the door system.

[0023] Each state that the elevator door can assume is represented graphically by a circle Mnemonics used within the circle identify a node as is described herein below.

[0024] A vector is the action or path the system must take in response to a set of conditions that are presented by the inputs or some other parameter that is being monitored. Each vector has the following characteristics:

a) Goto Node - Once conditions of a vector are met the machine is updated to the new node.
b) Vector Priority - All vectors out of a node are prioritized by the vector number; the lowest number having the highest priority.
c) Vector Conditions - All vectors have the following conditions:

1) Single Input conditions - Any input could be true or false, i.e., the condition must be true before the goto vector is executed. For example, a vector can be associated to the following condition:

V1:DS(T) which means vector 1 will be carried out if the signal DS equals the logical value of True.
V1:DS(F) which means vector 1 will be carried out if the signal DS equals the logical value of False.

2) Multiple conditions on one vector - If multiple conditions are present for a vector, a logical "AND" of all conditions is required to update to a new node, i.e. all conditions must be true before the goto vector is executed.

d) Data Functions - Each vector is capable of outputting to the memory some output data.
The following are the output capabilities of a vector:

- Door Performance Data - these are used by the abnormality detection logic to determine the door performance measures.
- Counts - This is count data of specific events such as:
  - Specific state counts - These are reported along with the performance measures.
  - Abnormality Counts - These are generated by the abnormality detection logic to which the vector interfaces.
  - Out of sequence counts

[0025] The sequences defined for each class of door types are essential to providing:

a) A means to determine proper door operation; i.e., the door followed a normal sequence of operation. For example, a door may open without a door open request; this is an incorrect sequence.
b) A means to measure raw door performance data that will be processed by the abnormality detection logic once the system is initialized.

[0026] Definitions for the mnemonics for the nodes of the state machine are as follows:

TABLE I

Definition of Node Mnemonics and Discrete Input Mnemonics	
Mnemonic	**Definition**
DCLS	Door Closed
DCO	Door Commanded to Open
DOG	Door Opening
DOP	Door Open
DCC	Door Close Command
DCG	Door Closing
DSCG	Door Stopped Closing
DCDS	Door Closed Before DS
DNIS	Doors Not in Service
DSOWC	Door Started to Open without Command
DS	Door Switch
DO	Door Open Relay
DOL	Door Open Limit Switch
DC	Door Close Relay
INOP	Elevator Inoperative
POW	Elevator Power On
SAF	Safety Chain Complete
SER	Elevator in Service

Table II

Definition of Door Performance Measure Mnemonics		
C1	Counter 1 - Start to Open Operations	This is the number of times a door Starts to Open
C2	Counter 2 - Open Interval Operations	This is the number of times a door opens
C3	Counter 3 - Dwell Operations	This is the number of times a door dwells
C4	Counter 4 - Start to Close Operations	This is the number of times a door Starts to close
C5	Counter 5 - Close Interval Operations	This is the number of times a door Closes
C6	Counter 6 - Reversal Counter	This is the number of times a door reverses
C7	Counter 7 - Door Open without Command Operation	This is the number of times a door opens without a request to open the door
I1	Interval 1 - Door Interlock Interval	This is the time from when the door is requested to open to when the door lock is detected to have opened
I2	Interval 2 - Door Open Interval	This is the time from when the door lock is open to when the door is full open
I3	Interval 3 - Door Dwell Interval	This is the time the door is full open
I4	Interval 4 - Door Start to Close Interval	This is the time from when the door is requested to close and when it begins to close
I5	Interval 5 - Door Close Interval	This is the time from when the door begins to close to actually when it is closed.

SEQUENCES OF STATE MACHINE OPERATION

Door Class 1

[0027] Referring now to Figure 3, a state machine model of an elevator door system in which transitions from state-to-state following a typical sequence of elevator door operations for the first class of elevator door systems is shown; namely, automatic doors with door open and door close command signals. The state machine described herein, in connection with Figure 3, in effect monitors substantially the entire sequence of operations that the elevator door performs. Thus, the state machine is the core logic and algorithm that models the normal behavior of the door system in an elevator system. If the elevator door fails to follow the normal sequence, or fails to meet the criteria for transitioning between successive states representative of normal operation, an inoperative condition or a failure condition is detected by a transition out of the normal sequence of states into an inoperative or alarm state.

[0028] A detailed description of the operation of the state machine follows. Each state in the diagram of Figure 3 is described along with the requirements and conditions for transition out of the state to another successive state. It should be understood that the actual hardware implementation of the state machine requires a programmer to encode all the requirements of the state machine in a particular language according to the particular hardware being used; however, the encoding details are not described because the particular hardware and programming techniques utilized are a matter of choice not embracing the inventive concept.

[0029] In the following description, any malfunction by the door or door controller which results in a failure to transition from a particular state in the normal sequence is detected. The specific transition out of the normal sequence is detected and identified by a transition to a particular inoperative condition. It should be kept in mind that the state machine serves a monitoring function whereas an actual failure of the elevator is the causal factor while the detection merely serves as a monitoring function of the elevator system.

[0030] START - When the system is initialized the door state machine starts at this node. This is also true for reset that may occur due to processor reset or a system reset from software. When DS(T) is observed by the system it moves to the next node.

[0031] DCLS - This node is the door closed node. Whenever the door is locked and the door chain is complete the system is in this node. A DO(T) condition will move us to the DCO node. A DS(F) Condition at this state will take the system to the DSOWC node and update Counter 7 (C7) (door opened without command counter).

[0032] DCO - This is the Door Commanded to Open node. The system is at this node whenever the door is legally

requested to open. A DO(F) condition at this node will move us back to DCLS node. A DS(F) condition will move us to the DOG Node. As we move to the DOG node we update Interval 1(I1) and counter 1 1 (C1).

[0033] DOG - Door Opening Node. Whenever the door is opening the system is at this node. A DOL(T) condition moves the system to the DOP state and updates I2 and C2. If a DC(T) and DO(F) condition is detected then the system moves to the DCC node and updates counter 4 (C4). If a DS(T) condition is detected then we move to node DCLS.

[0034] DOP - Door Open Node. Whenever the doors are functionally open the system is at this node. If a DC(T) and DO(F) condition are detected then the system moves to DCC node and updates I3 and C3. If a DS(T) condition is detected the system moves to DCLS node.

[0035] DCC - Door Commanded to Close Node. Whenever the Doors are legally requested to close the system is at this node. If a DC(F) condition is detected the system returns to DOG node. If DOL(F) condition is detected the system moves to DCG node and updates I4 and C4. If a DS(T) condition is detected the system moves to DCLS node.

[0036] DCG - Door Closing Node. When the doors are in closing mode the system will be at this node. If DC(F) condition is detected the system moves to DSCG node and updates I5 and C5. If DS(T) condition is detected the system moves to DCDS node and updates I5 and C5. IF DO(T) condition is detected the system returns to DOG state and updates the reversal counter (C6).

[0037] DSCG - Door Stopped Closing. When the system detects the Doors are closed we are at this node. When DO(T) is detected the system returns to node DOG and updates reversal counter (C6). If DS(T) is detected then the system moves to DCLS node.

[0038] DCDS - This node represents doors closed before the Door Close Command is detected off. This node allows the system to monitor door operators that have a slightly different mode of operation where the command to close is turned off after the doors are closed. If a DC(F) (door Close relay false) condition is detected here the system moves to DCLS node.

[0039] DSOWC - Doors started to Open without command. This is a failure node. If DS(T) is detected the system returns to DCLS node. If the system observes a DO(T) condition then it moves to DCO node.

[0040] DNIS - If an external input from a supervisory system or from the elevator goes true INOP(T) is detected and the system is at this node. The door state machine will desynchronize from this failure node back to the above described sequence when it detects POW(T), SAF(T) and DS(T) and it moves to state DCLS.

Door Class 2

[0041] Referring to Figure 4, a state machine model of an elevator door system in which transitions from state-to-state following a typical sequence of elevator door operations for the second class of elevator door systems is shown; namely, automatic doors with door open command. A detailed description of the state machine follows.

[0042] START - When the system is initialized the door state machine starts at this node. This is also true for reset that may occur due to processor reset or a system reset from software. When DS(T) is observed by the system it moves to the next node.

[0043] DCLS - This node is the door closed node. Whenever the door is locked and the door chain is complete the system is in this node. A DO(T) condition will move us to the DCO node. A DS(F) Condition at this state will take the system to the DSOWC node and update Counter 7 (C7) (door opened without command counter).

[0044] DCO - This is the Door Commanded to Open node. The system is at this node whenever the door is legally requested to open. A DO(F) condition at this node will move us back to DCLS node. A DS(F) condition will move us to the DOG Node. As we move to the DOG node we update Interval 1(I1) and counter 1 (C1).

[0045] DOG - Door Opening Node. Whenever the door is opening the system is at this node. A DOL(T) condition moves the system to the DOP state and updates I2 and C2. If a DO(F) condition is detected then the system moves to the DCC node and updates counter 4 (C4). If a DS(T) condition is detected then we move to node DCLS.

[0046] DOP - Door Open Node. Whenever the doors are functionally open the system is at this node. If a DO(F) condition is detected then the system moves to DCC node and updates I3 and C3. If a DS(T) condition is detected the system moves to DCLS node.

[0047] DCC - Door Commanded to Close Node. Whenever the Doors are legally requested to close the system is at this node. If a DO(T) condition is detected the system returns to DOG node. If DOL(F) condition is detected the system moves to DCG node and updates I4 and C4. If a DS(T) condition is detected the system moves to DCLS node.

[0048] DCG - Door Closing Node. When the doors are in closing mode the system will be at this node. If DS (T) condition is detected the system moves to DCLS node and updates I5 and C5. IF DO(T) condition is detected the system returns to DOG state and updates the reversal counter (C6).

[0049] DSOWC - Doors started to Open without command. This is a failure node. If DS(T) is detected the system returns to DCLS node. If the system observes a DO(T) condition then it moves to DCO node.

[0050] DNIS - If an external input from a supervisory system or from the elevator goes true INOP(T) is detected and the system is at this node. The door state machine will desynchronize from this failure node back to the above described

sequence when it detects POW(T), SAF(T) and DS(T) and it moves to state DCLS.

Door Class 3

[0051] Referring to Figure 5, a state machine model of an elevator door system in which transitions from state-to-state following a typical sequence of elevator door operations for the third class of elevator door systems is shown; namely, simple automatic doors. A detailed description of the state machine follows.

[0052] START - When the system is initialized the door state machine starts at this node. This is also true for reset that may occur due to processor reset or just a system reset from software. When DS(T) is observed by the system it moves to the next node.

[0053] DCLS - This node is the door closed node. Whenever the door is locked and the door chain is complete the system is in this node. A DO(T) condition will move us to the DCO node. A DS(F) Condition at this state will take the system to the DSOWC node and update Counter 7 (C7) (door opened without command counter).

[0054] DCO - This is the Door Commanded to Open node. The system is at this node whenever the door is legally requested to open. A DO(F) condition at this node will move us back to DCLS node. A DS(F) condition will move us to the DOP Node. As we move to the DOP node we update Interval 1 (I1) and counter 1 (CI).

[0055] DOP - Door Open Node. Whenever the doors are functionally open the system is at this node. If a DO(F) condition is detected then the system moves to DCC node and updates I3 and C3. If DS(T) is detected, the system moves to DCLS.

[0056] DCC - Door Commanded to Close. When the doors are in closing mode the system will be at this node. If DS (T) condition is detected the system moves to DCLS node and updates I5 and C5. IF DO(T) condition is detected the system returns to DOP state and updates the reversal counter (C6).

[0057] DSOWC - Doors started to Open without command. This is a failure node. If DS(T) is detected the system returns to DCLS node. If the system observes a DO(T) condition then it moves to DCO node.

[0058] DNIS - If an external input from a supervisory system or from the elevator goes true INOP(T) is detected and the system is at this node. The door state machine will desynchronize from this failure node back to the above described sequence when it detects POW(T), SAF(T) and DS(T) and it moves to state DCLS.

INITIALIZATION

[0059] For a given operator the first n door operations that go through the correct sequence of discrete events are defined as "valid operations". The advantage of verifying the sequence of operation is twofold. First, empirical elevator knowledge is used to determine whether a normal door operation occurred. Second, non-normal door operations such as reversals are automatically removed from the initial data set. The median of the sorted timings from the first n "valid operations" at each door can be computed as an estimate of the real mean. This initial mean, in one embodiment, is used as a reference measure. An estimate of the standard deviation is obtained by the median of the sorted data set (estimated mean). This initial standard deviation, in one embodiment, is used as an initial acceptable range for a performance measure and is determined in response to the reference measure. The advantages of this initialization routine are that it is flexible, accurate, and statistically robust. Accordingly, the purpose of the initialization logic is to provide a reference measure as a starting point for the performance measure, and to provide the acceptable range for the performance measure.

Median Filter Technique

[0060] The median filter technique requires a series of data points to be collected and stored into a table. When the table is full (number of data points = n), the data is sorted. The median point, in the sorted data, is used as an approximation of the initial mean point which is defined as the reference measure.

[0061] The initial acceptable range is a fraction of the variance of the data points within the table. The initial acceptable range for abnormality detection is determined as follows:

$$StD_i = \sqrt{\frac{n}{n-1}}\, median\ |(x_i - x_m)|$$

where:

x_I = data point
X_m = median point (reference measure)

n = width of data set

[0062] A sample calculation of the starting mean and standard deviation technique is as follows:

1) Data points are collected and stored in the table.

3.25	3.45	3.10	3.25	3.96	2.96	3.56	4.01	3.67	3.12	3.80

2) When the table is full the data points are sorted.

2.96	3.10	3.12	3.25	3.25	3.45	3.56	3.67	3.80	3.96	4.01

3) Median point = 3.45

4) Standard deviation calculation.

x_m	x_i	$\lvert x_m-x_i\rvert$	$\lvert x_m-x_i\rvert$ sorted
3.45	2.96	.49	.00
3.45	3.10	.35	.11
3.45	3.12	.33	.20
3.45	3.25	.20	.20
3.45	3.25	.20	.22
3.45	3.45	.00	.33
3.45	3.56	.11	.35
3.45	3.67	.22	.35
3.45	3.80	.35	.49
3.45	3.96	.51	.51
3.45	4.01	.56	.56

$$StD_i = \sqrt{1.1}\,(.33) = .35$$

Application of the Median Filter Technique.

[0063] The door diagnostics logic requires an initial mean and standard deviations to be established for each interval. Initial values only have to be established if the system has not been initialized. In one embodiment, the width of the median filter is eleven points.

[0064] The door state machine is used to filter erroneous data points from median filter logic. Data points collected from abnormal state sequences are not stored in the median filter table. The first eleven normal door operations, at any floor, are used in this embodiment to establish the initial mean and standard deviation values for all doors.

ABNORMALITY DETECTION LOGIC

Mean and Standard Deviation Calculation

[0065] During steady state operation the mean and standard deviation values are updated using a continuous filter technique.

[0066] The new mean A_t is continuously updated by taking a fraction of the old mean A_{t-1} plus a fraction of the new data point X_t. Thus, a new processed performance measure ("performance result") for any given interval is determined as follows:

$$A_t = \left(\frac{n-1}{n}\right) * A_{t-1} + \left(\frac{1}{n}\right) * X_t$$

where:

t is the present time,
t-1 is the time of previous evaluation,
X_t is the performance measure,
A_t is the performance result, and
n is the number of values in the average, also defined as the width of the filter. In one embodiment, the width of the filter ranges from 1 to 20.

[0067] The new mean ("performance result") A_t is used to calculate new standard deviation StD_t. The standard deviation StD_t for abnormality determination is derived as follows:

$$StD_t = \sqrt{\left(\frac{n-1}{n}\right) * (StD_{t-1})^2 + \left(\frac{1}{n}\right) * (A_t - X_t)^2}$$

[0068] Only the immediately preceding values of the mean, A_{t-1}, and standard deviation, StD_{t-1}, need be recorded in order to determined the current values of A_t and StD_t.

Abnormality Determination

[0069] Abnormalities in the interval data from the state machine are data points that differ from the mean by a multiple G of the standard deviations StD_t. Thus, an acceptable range of $G*StD_t$ is used to determine abnormalities. The relationship is as follows:

$$\text{IF } (|A_{t-1} - X_t|) \geq G * StD_{t-1} \text{ THEN } X_t$$

is an abnormality

[0070] The acceptable range has a minimum value in order to prevent all data points being determined as abnormal. For example, if the acceptable range reaches zero then all data points will be outside of the acceptable range. In one embodiment, the minimum value is proportional to the sample rate of the performance measures.

[0071] Additionally, if the number of abnormalities is greater than a determined number then the acceptable range is increased by a determined percentage. In one embodiment, the determined number is fifty percent of a total number of iterations. The determined percentage may be ten per cent. Abnormalities are not considered in the calculations of new mean and standard deviation.

Gain Factor (G)

[0072] The gain factor is used to determine the number of standard deviations away from the mean a data point can be before it is classified an abnormality. In one embodiment, the gain in the door diagnostics logic is set to eleven.

OUTPUT PROCESSING

Door Performance Measures

[0073] The counts, interval means and standard deviations are transferred to data storage for each performance data update. A performance data update occurs after the system detects a predetermined number of door operations so that the performance result may be further refined. In one embodiment, the predetermined number of times is 50. The data are stored in performance bins that are eventually sent to the local office for data analysis and maintenance scheduling. Counters are updated by adding one to the previously stored count. Intervals are stored in a working bin and when a performance update occurs the interval data is averaged and both the mean and standard deviation is

stored in memory.

Door Status Outputs

[0074] According to each sequence of the various door state machine models, every time the door state machine updates to a new node, the door status is updated with a new door status according to the following table:

TABLE III

Node Mnemonic	Door Status Output
START	None
DCLS	Door Closed
DCO	Door Commanded to Open
DOG	Door Opening
DOP	Door Open
DCC	Door Open
DCG	Door Closing
DSCG	Door Closing
DCDS	Door Closed
DSOWC	Door Closing
DNIS	Door Closing

[0075] The door performance results and the door status outputs are useful in determining the existence of an alarm condition, determining the cause of the alarm condition and prevention of future alarm conditions.

[0076] Thus, the present invention provides the advantage of accurately monitoring elevator door performance results in addition to monitoring alarm conditions caused by elevator door faults; this allows for the detection of elevator door system degradation over a period of time. Additionally, the present invention provides the ability to monitor a plurality of different elevator door systems having a plurality of different parameter signals to be monitored.

Claims

1. A method for providing an elevator door performance result of an elevator door in an elevator system, said method comprising the steps of:

   determining a reference measure (X_m, A_{t-1}) for the elevator door;
   determining an acceptable range ($G*StD_{t-1}$) for a performance measure (X_t) in response to the reference measure;
   providing the performance measure (X_t) from a door state machine which monitors a plurality of parameter signals provided by the elevator door system, the door state machine following a sequence of elevator door operations;
   determining if the performance measure (X_t) is within the acceptable range; and
   providing a performance result (A_t) by averaging the performance measure (X_t) with the reference measure (X_m, A_{t-1}) if the performance measure is within the acceptable range, wherein the performance measure is not considered in providing the performance result if the performance measure is not within the acceptable range.

2. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 1 wherein the performance result is determined in accordance with the following:

$$A_t = \left(\frac{n-1}{n}\right) * A_{t-1} + \left(\frac{1}{n}\right) * X_t$$

wherein

t is the present time,
t-1 is the time of previous evaluation,
X_t is the performance measure,
A_t is the performance result, and
n is the number of values in the average.

3. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 1 or 2 wherein the number of values in the average ranges from one to twenty.

4. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 1, 2 or 3 wherein the acceptable range is determined in accordance with the following:

$$\text{Acceptable Range} = G*StD_t = G*\sqrt{\left(\frac{n-1}{n}\right) * (StD_{t-1})^2 + \left(\frac{1}{n}\right) * (A_t - X_t)^2}$$

wherein

t is the present time,
t-1 is the time of previous evaluation,
X_t is the performance measure,
A_t is the performance result,
StD_t is the standard deviation,
G is a gain factor, and
n is the number of values in the average.

5. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 1 further comprising the step of:

providing an updated acceptable range in response to the average of the performance measure and the reference measure.

6. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein each step is repeated a determined number of iterations so as to further refine the performance result.

7. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 6 wherein if a number of occurrences of the performance measure not being in the acceptable range is greater than a determined number then the acceptable range is increased by a determined percentage.

8. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 7 wherein the determined number is fifty percent of the determined number of iterations.

9. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 7 or 8 wherein the determined percentage is ten percent.

10. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 6 wherein the determined number of iterations is 50.

11. A method for providing an elevator door performance result of an elevator door in an elevator system as recited

in any preceding claim wherein the performance measure is a door interlock interval.

12. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the performance measure is a door open interval.

13. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the performance measure is a door dwell interval.

14. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the performance measure is a door start to close interval.

15. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the performance measure is a door close interval.

16. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the parameter signals monitored by the door state machine include a door open command signal and a door switch signal.

17. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the parameter signals monitored by the door state machine include a door open limit signal.

18. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the parameter signals monitored by the door state machine include a door close command signal.

19. A method for providing an elevator door performance result of an elevator door in an elevator system as recited in any preceding claim wherein the performance result is communicated from a building in which the elevator system resides to a monitoring center for determining degradation in the performance result.

20. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system which normally operates sequentially from state-to-state in a closed loop sequential chain of normal operating states, said apparatus monitoring a plurality of parameter signals provided by the elevator door system, said apparatus comprising:

a door state sequencer for providing a performance measure (X_t) in response to a plurality of parameter signals provided by the elevator door system;
a module for providing a reference measure (X_m, A_{t-1}) and an acceptable range ($G*StD_{t-1}$) for the door performance measure in response to the sequential chain of normal door operating states; and
an abnormal detection module for analyzing the door performance measure (X_t) such that if the door performance measure is within the acceptable range a performance result (A_t) is provided by averaging the performance measure with the reference measure.

21. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in claim 20 wherein the acceptable range is updated in response to the performance result.

22. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in claim 20 or 21 wherein if the door performance measure is not within the acceptable range, the door performance measure is ignored.

23. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in claim 20, 21 or 22 wherein the performance result is determined in accordance with the following:

$$A_t = \left(\frac{n-1}{n}\right) * A_{t-1} + \left(\frac{1}{n}\right) * X_t$$

wherein

t is the present time,
t-1 is the time of previous evaluation,
X_t is the performance measure,
A_t is the performance result, and
n is the number of values in the average.

24. An apparatus for providing an elevator door performance result of an elevator door in an elevator system as recited in claim 23 wherein the number of values in the average ranges from one to twenty.

25. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 24 wherein the acceptable range is determined in accordance with the following:

$$\text{Acceptable Range} = G*StD_t = G*\sqrt{\left(\frac{n-1}{n}\right)*(StD_{t-1})^2+\left(\frac{1}{n}\right)*(A_t-X_t)^2}$$

wherein

t is the present time
t-1 is the time of previous evaluation,
X_t is the performance measure,
A_t is the performance result,
StD_t is the standard deviation,
G is a gain factor, and
n is the number of values in the average.

26. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 25 wherein the performance measure is a door interlock interval.

27. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 26 wherein the performance measure is a door open interval.

28. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 27 wherein the performance measure is a door dwell interval.

29. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 28 wherein the performance measure is a door start to close interval.

30. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 29 wherein the performance measure is a door close interval.

31. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 30 wherein the parameter signals monitored by the door state sequencer comprise a door open command signal and a door switch signal.

32. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 31 wherein the parameter signals monitored by the door state sequencer include a door open limit signal.

33. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as recited in any of claims 20 to 32 wherein the parameter signals monitored by the door state sequencer include a door close command signal.

34. An apparatus for providing an elevator door performance result of an elevator door in an elevator door system as

recited in any of claims 20 to 33 wherein the performance result is communicated from a building in which the elevator system resides to a monitoring center for determining degradation in the performance result.

Patentansprüche

1. Verfahren zum Bereitstellen eines Aufzugtürleistungsergebnisses für eine Aufzugtür in einem Aufzugsystem, umfassend folgende Schritte:

   Bestimmen eines Referenzmaßes (X_m, A_{t-1}) für die Aufzugtür;
   Bestimmen eines Akzeptierbarkeitsbereichs ($G*StD_{t-1}$) für ein Leistungsmaß (X_t) ansprechend auf das Referenzmaß;
   Bereitstellen des Leistungsmaßes (X_t) aus einer Türzustandsmaschine, die mehrere Parametersignale, die von dem Aufzugtürsystem kommen, überwacht, wobei die Türzustandsmaschine einer Sequenz von Aufzugtüroperationen folgt;
   Ermitteln, ob das Leistungsmaß (X_t) innerhalb des Akzeptierbarkeitsbereichs liegt; und
   Bereitstellen eines Leistungsergebnisses (A_t) durch Mitteln des Leistungsmaßes (X_t) mit dem Referenzmaß (X_m, A_{t-1}), wenn das Leistungsmaß innerhalb des Akzeptierbarkeitsbereichs liegt, wobei das Leistungsmaß bei der Bereitstellung des Leistungsergebnisses nicht berücksichtigt wird, wenn das Leistungsmaß nicht innerhalb des Akzeptierbarkeitsbereichs liegt.

2. Verfahren nach Anspruch 1, bei dem das Leistungsergebnis gemäß folgender Beziehung ermittelt wird:

$$A_t = \left(\frac{n-1}{n}\right) * A_{t-1} + \left(\frac{1}{n}\right) * X_t$$

   wobei

t	die laufende Zeit ist,
t-1	die Zeit der vorausgehenden Auswertung ist,
X_1	das Leistungsmaß ist,
A_t	das Leistungsergebnis ist, und
n	die Anzahl von Werten in der Mittelung ist.

3. Verfahren nach Anspruch 1 oder 2, bei dem die Anzahl von Werten der Mittelung von eins bis zwanzig reicht.

4. Verfahren nach Anspruch 1, 2 oder 3, bei dem der Akzeptierbarkeitsbereich gemäß folgender Beziehung ermittelt wird:

$$\text{Akzeptierbarkeits-bereich} = G*StD_t = G*\sqrt{\left(\frac{n-1}{n}\right) * (StD_{t-1})^2 + \left(\frac{}{n}\right)^1 * (A_t - X_t)^2}$$

   wobei

t	die laufende Zeit ist,
t-1	die Zeit der vorausgehenden Auswertung ist,
X_1	das Leistungsmaß ist,
A,	das Leistungsergebnis ist,
StD_t	die Standardabweichung ist,

G ein Verstärkungsfaktor ist, und
n die Anzahl von Werten in der Mittelung ist.

5. Verfahren nach Anspruch 1, weiterhin umfassend den Schritt:

   Bereitstellen eines aktualisierten Akzeptierbarkeitsbereichs ansprechend auf die Mittelung des Leistungsmaßes und des Referenzmaßes.

6. Verfahren nach einem vorhergehenden Anspruch, bei dem jeder Schritt mit einer vorbestimmten Anzahl von Iterationen wiederholt wird, um das Leistungsergebnis zu verfeinern.

7. Verfahren nach Anspruch 6, bei dem, wenn eine Häufigkeit des Auftretens des Leistungsmaßes, das nicht in dem Akzeptierbarkeitsbereich liegt, größer als eine vorbestimmte Anzahl ist, der Akzeptierbarkeitsbereich um einen vorbestimmten Prozentsatz vergrößert wird.

8. Verfahren nach Anspruch 7, bei dem die vorbestimmte Anzahl fünfzig Prozent der vorbestimmten Anzahl von Iterationen ist.

9. Verfahren nach Anspruch 7 oder 8, bei dem der vorbestimmte Prozentsatz zehn Prozent beträgt.

10. Verfahren nach Anspruch 6, bei dem die vorbestimmte Anzahl von Iterationen 50 beträgt.

11. Verfahren nach einem vorhergehenden Anspruch, bei dem das Leistungsmaß ein Türverrieglungsintervall ist.

12. Verfahren nach einem vorhergehenden Anspruch, bei dem das Leistungsmaß ein Türöffnungsintervall ist.

13. Verfahren nach einem vorhergehenden Anspruch, bei dem das Leistungsmaß ein Türhalteintervall ist.

14. Verfahren nach einem vorhergehenden Anspruch, bei dem das Leistungsmaß ein Tür-Schließbeginn-Intervall ist.

15. Verfahren nach einem der vorhergehenden Ansprüche, bei dem das Leistungsmaß ein Türschließintervall ist.

16. Verfahren nach einem vorhergehenden Anspruch, bei dem die Parametersignale, die von der Zustandsmaschine überwacht werden, ein Türöffnungsbefehlssignal und ein Türschaltsignal enthalten.

17. Verfahren nach einem vorhergehenden Anspruch, bei dem die von der Türzustandsmaschine überwachten Parametersignale ein Türöffnungs-Grenzsignal enthalten.

18. Verfahren nach einem vorhergehenden Anspruch, bei dem die von der Türzustandsmaschine überwachten Parametersignale ein Türschließ-Befehlssignal enthalten.

19. Verfahren nach einem vorhergehenden Anspruch, bei dem das Leistungsergebnis von einem Gebäude, in welchem sich das Aufzugsystem befindet, zu einem Überwachungszentrum übertragen wird, um eine Verschlechterung des Leistungsergebnisses zu ermitteln.

20. Vorrichtung zur Bereitstellung eines Aufzugtür-Leistungsergebnisses einer Aufzugtür in einem Aufzugtürsystem, das normalerweise sequenziell von einem Zustand zum anderen Zustand in einer eine geschlossene Schleife bildenden sequenziellen Kette von normalen Betriebszuständen arbeitet, wobei die Vorrichtung mehrere Parametersignale überwacht, die von dem Aufzugtürsystem geliefert werden, umfassend:

   eine Türzustandsablaufsteuerung zum Liefern eines Leistungsmaßes (X_t) ansprechend auf die von dem Aufzugtürsystem gelieferten mehreren Parameter-signalen;
   ein Modul zum Bereitstellen eines Referenzmaßes (X_m, A_{t-1}) und eines Akzeptierbarkeitsbereichs ($G*StD_{t-1}$) für das Türleistungsmaß ansprechend auf die sequenzielle Kette von normalen Türbetriebszuständen;
   ein Abnormalitäts-Detektormodul zum Analysieren des Türleistungsmaßes (X_t) derart, daß dann, wenn das Türleistungsmaß innerhalb des Akzeptierbarkeitsbereichs liegt, ein Leistungsergebnis (A_t) bereitgestellt wird durch Mitteln des Leistungsmaßes mit dem Referenzmaß.

21. Vorrichtung nach Anspruch 20, bei dem der Akzeptierbarkeitsbereich abhängig von dem Leistungsergebnis aktualisiert wird.

22. Vorrichtung nach Anspruch 20 oder 21, bei der dann, wenn das Türleistungsmaß nicht innerhalb des Akzeptierbarkeitsbereichs liegt, das Türleistungsmaß ignoriert wird.

23. Vorrichtung nach Anspruch 20, 21, oder 22, bei der das Leistungsergebnis gemäß folgender Beziehung ermittelt wird:

$$A_t = \left(\frac{n-1}{n}\right) * A_{t-1} + \left(\frac{1}{n}\right) * X_t$$

wobei

t	die laufende Zeit ist,
$t-1$	die Zeit der vorausgehenden Auswertung ist,
X_1	das Leistungsmaß ist,
A_t	das Leistungsergebnis ist, und
n	n die Anzahl von Werten bei der Mittelung ist.

24. Vorrichtung nach Anspruch 23, bei der die Anzahl von Werten bei der Mittelung von eins bis zwanzig reicht.

25. Vorrichtung nach einem der Ansprüche 20 bis 24, bei der der Akzeptierbarkeitsbereich nach folgender Beziehung ermittelt wird:

$$\text{Akzeptierbarkeitsbereich} = G*StD_t = G*\sqrt{\left(\frac{n-1}{n}\right) * (StD_{t-1})^2 + \left(\frac{1}{n}\right) * (A_t - X_t)^2}$$

wobei

t	die laufende Zeit ist,
$t-1$	die Zeit der vorausgehenden Auswertung ist,
X_1	das Leistungsmaß ist,
A_t	das Leistungsergebnis ist,
StD_t	die Standardabweichung ist,
G	ein Verstärkungsfaktor ist, und
n	die Anzahl von Werten in der Mittelung ist.

26. Vorrichtung nach einem der Ansprüche 20 bis 25, bei der das Leistungsmaß ein Türverriegelungsintervall ist.

27. Vorrichtung nach einem der Ansprüche 20 bis 26, bei der das Leistungsmaß ein Türöffnungsintervall ist.

28. Vorrichtung nach einem der Ansprüche 20 bis 27, bei der das Leistungsmaß ein Türhalteintervall ist.

29. Vorrichtung nach einem der Ansprüche 20 bis 28, bei der das Leistungsmaß ein Tür-Schließbeginn-Intervall ist.

30. Vorrichtung nach einem der Ansprüche 20 bis 29, bei der das Leistungsmaß ein Türschließintervall ist.

31. Vorrichtung nach einem der Ansprüche 20 bis 30, bei der die von der Türzustands-Ablaufsteuerung überwachten Parametersignale ein Türöffnungs-Befehlssignal und ein Türschaltsignal aufweisen.

32. Vorrichtung nach einem der Ansprüche 20 bis 31, bei der die Parametersignale, die von der Türzustands-Ablaufsteuerung überwacht werden, ein Türöffnungs-Grenzsignal enthalten.

33. Vorrichtung nach einem der Ansprüche 20 bis 32, bei der die von der Türzustands-Ablaufsteuerung überwachten Parametersignale ein Türschließ-Befehlssignal enthalten.

34. Vorrichtung nach einem der Ansprüche 20 bis 33, bei dem das Leistungsergebnis von einem Gebäude, in dem sich das Aufzugsystem befindet, zu einem Überwachungszentrum übermittelt wird, um eine Verschlechterung des Leistungsergebnisses zu ermitteln.

Revendications

1. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur, ledit procédé comprenant les étapes consistant à :

   déterminer une mesure de référence (X_m,A_{t-1}) pour la porte d'ascenseur ;
   déterminer une plage acceptable (G*StD_{t-1}) pour une mesure de performance (X_t) en réponse à la mesure de référence ;
   fournir la mesure de performance (X_t) à partir d'une machine d'état de porte qui surveille une pluralité de signaux de paramètres délivrés par le système de porte d'ascenseur, la machine d'état de porte suivant une séquence d'opérations de la porte d'ascenseur ;
   déterminer si la mesure de performance (X_t) est à l'intérieur de la plage acceptable ; et
   délivrer un résultat de performance (A_t) en mettant en moyenne la mesure de performance (X_t) avec la mesure de référence (X_m,A_{t-1}) si la mesure de performance est à l'intérieur de la plage acceptable, dans lequel la mesure de performance n'est pas considérée comme délivrant le résultat de la performance si la mesure de performance n'est pas à l'intérieur de la plage acceptable.

2. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 1, dans lequel le résultat de la performance est déterminé en conformité par :

$$A_t = \left(\frac{n-1}{n}\right) * A_{t-1} + \left(\frac{1}{n}\right) * X_t$$

   où

   t est le temps présent,
   t-1 est le temps de l'évaluation précédente,
   X_t est la mesure de la performance,
   A_t est le résultat de la performance, et
   n est le nombre de valeurs en moyenne.

3. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 1 ou 2, dans lequel le nombre des valeurs dans les plages moyennes vont de un à vingt.

4. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 1, 2 ou 3, dans lequel la plage acceptable est déterminée en par :

$$\text{Plage acceptable} = G*StD_t = G*\sqrt{\left(\frac{n-1}{n}\right)*(StD_{t-1})^2+\left(\frac{1}{n}\right)*(A_t-X_t)^2}$$

où

t est le temps présent,
t-1 est le temps de l'évaluation précédente,
X_t est la mesure de la performance,
A_t est le résultat de la performance,
StD_t est l'écart-type,
G est un facteur de gain, et
n est le nombre de valeurs en moyenne.

5. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 1, comprenant, en outre, l'étape consistant à :

   fournir une plage acceptable mise à jour en réponse à la moyenne de la mesure de performance et de la mesure de référence.

6. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel chaque étape est répétée à un nombre déterminé d'itérations de façon à affiner davantage le résultat de la performance.

7. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 6, dans lequel si un nombre d'occurrences de la mesure de la performance ne se trouvant pas dans la plage acceptable est supérieur à un nombre déterminé, alors, la plage acceptable est accrue d'un pourcentage déterminé.

8. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 7, dans lequel le nombre déterminé est de cinquante pour cent du nombre déterminé d'itérations.

9. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 7 ou 8, dans lequel le pourcentage déterminé est de dix pour cent.

10. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 6, dans lequel le nombre déterminé d'itérations est de 50.

11. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel la mesure de la performance est un intervalle d'interverrouillage des portes.

12. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel la mesure de la performance est un intervalle d'ouverture des portes.

13. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel la mesure de la performance est un intervalle de passage de la porte.

14. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel la mesure de la performance est un intervalle de début à fermeture de porte.

15. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel la mesure de la performance est un intervalle de fermeture de porte.

16. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel les signaux de paramètres surveillés par la machine d'état de porte incluent un signal d'ordre d'ouverture de porte et un signal de commutateur

de porte.

17. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel les signaux de paramètres surveillés par la machine d'état de porte incluent un signal limite d'ouverture de porte.

18. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel les signaux de paramètres surveillés par la machine d'état de porte incluent un signal d'ordre de fermeture de porte.

19. Procédé pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel le résultat de la performance est communiqué à partir d'un immeuble dans lequel se trouve le système d'ascenseur à un centre de surveillance pour déterminer la détérioration du résultat de la performance.

20. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur qui opère normalement séquentiellement d'état à état en une chaîne séquentielle de boucles fermées d'états fonctionnels normaux, ledit dispositif surveillant une pluralité de signaux de paramètres délivrés par le système de porte d'ascenseur, ledit dispositif comprenant :

un séquenceur d'état de porte pour délivrer une mesure de la performance (X_t) en réponse à une pluralité de signaux de paramètres délivrés par le système de porte d'ascenseur ;
un module de détection d'anomalie pour analyser la mesure de la performance de la porte (X_t) d'une manière telle que si la mesure de la performance de la porte est à l'intérieur de la plage acceptable, un résultat de la performance (A_t) est délivré en mettant en moyenne la mesure de la performance avec la mesure de référence.

21. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon la revendication 20, dans lequel la plage acceptable est mise à jour en réponse au résultat de la performance.

22. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon la revendication 20 ou 21, dans lequel si la mesure de la performance de la porte n'est pas à l'intérieur de la plage acceptable, la mesure de la performance de la porte est ignorée.

23. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon la revendication 20, 21 ou 22, dans lequel le résultat de la performance est déterminé par :

$$A_t = \left(\frac{n-1}{n}\right) * A_{t-1} + \left(\frac{1}{n}\right) * X_t$$

où

t est le temps présent,
t-1 est le temps de l'évaluation précédente,
X_t est la mesure de la performance,
A_t est le résultat de la performance, et
n est le nombre des valeurs dans la moyenne.

24. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système d'ascenseur selon la revendication 23, dans lequel le nombre des valeurs dans la moyenne s'étale de un à vingt.

25. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 24, dans lequel la plage acceptable est déterminée par :

$$\text{Plage acceptable} = G*StD_t = G*\sqrt{\left(\frac{n-1}{n}\right)*(StD_{t-1})^2+\left(\frac{1}{n}\right)*(A_t-X_t)^2}$$

où

t est le temps présent,
t-1 est le temps de l'évaluation précédente,
X_t est la mesure de la performance,
A_t est le résultat de la performance,
StD_t est l'écart-type,
G est un facteur de gain, et
n est le nombre des valeurs dans la moyenne.

26. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 25, dans lequel la mesure de la performance est un intervalle d'interverrouillage des portes.

27. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 26, dans lequel la mesure de la performance est un intervalle d'ouverture de porte.

28. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 27, dans lequel la mesure de la performance est un intervalle de passage de porte.

29. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 28, dans lequel la mesure de la performance est un intervalle du commencement de l'ouverture à la fermeture de la porte.

30. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 29, dans lequel la mesure de la performance est un intervalle de fermeture de porte.

31. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 30, dans lequel les signaux de paramètres surveillés par le séquenceur d'état de porte comprennent un signal d'ordre d'ouverture de porte et un signal de commutation de porte.

32. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 31, dans lequel les signaux de paramètres surveillés par le séquenceur d'état de porte incluent un signal limite d'ouverture de porte.

33. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 32, dans lequel les signaux de paramètres surveillés par le séquenceur d'état de porte incluent un signal d'ordre de fermeture de porte.

34. Dispositif pour fournir un résultat de performance de porte d'ascenseur d'une porte d'ascenseur dans un système de porte d'ascenseur selon l'une quelconque des revendications 20 à 33, dans lequel le résultat de la performance est communiqué depuis un immeuble dans lequel se trouve le système d'ascenseur à un centre de surveillance pour déterminer la détérioration du résultat de la performance.

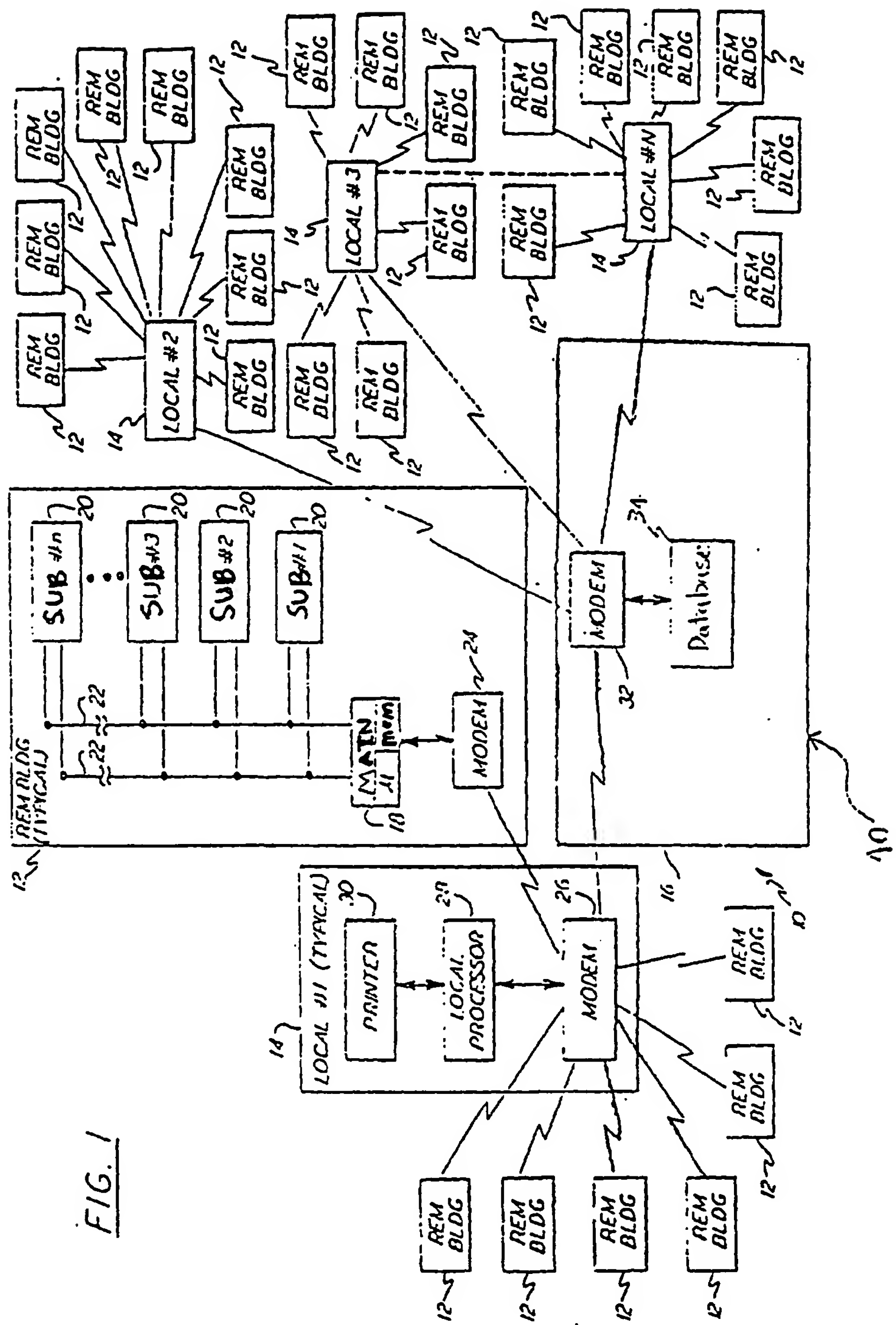
REM BLDG
LOCAL #2
LOCAL #3
LOCAL #N
REM BLDG (TYPICAL)
SUB #n
SUB #3
SUB #2
SUB #1
MAIN
MODEM
Database
LOCAL #1 (TYPICAL)
PRINTER
LOCAL PROCESSOR
MODEM

FIG. 1

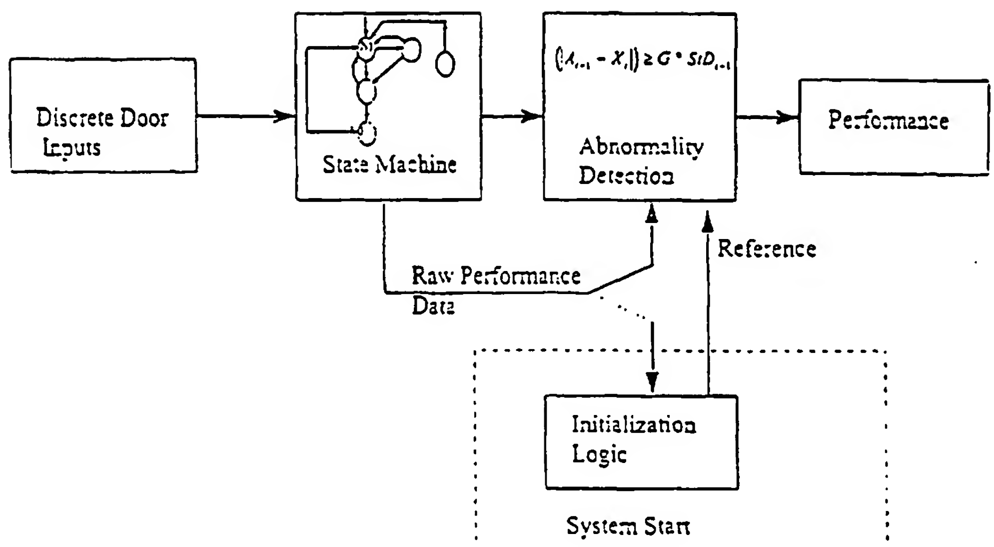
Discrete Door Inputs
State Machine
$(|X_{i-1} - X_i|) \geq G \cdot StD_{i-1}$
Abnormality Detection
Performance
Raw Performance Data
Reference
Initialization Logic
System Start

FIG2

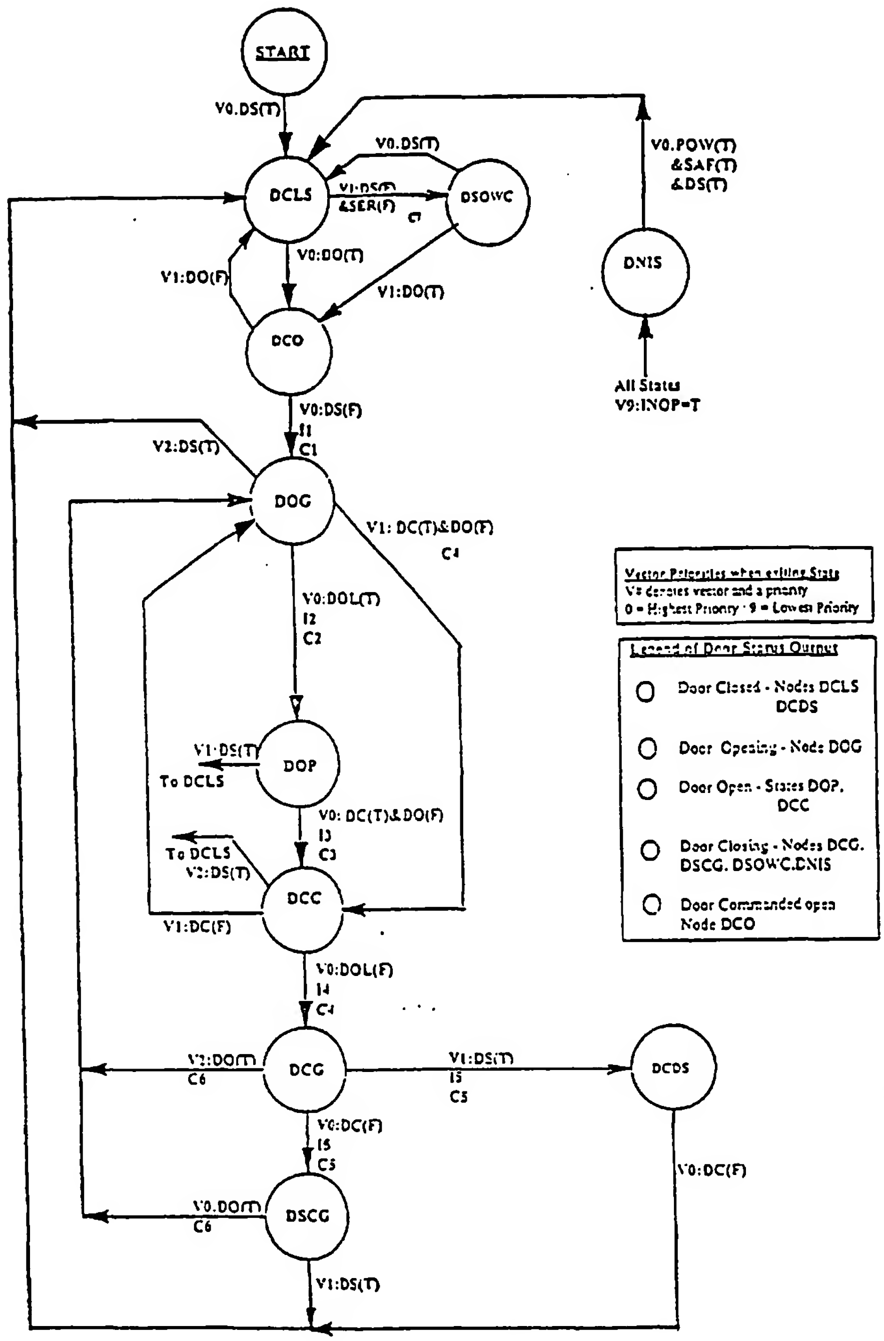
START
V0.DS(T)
DCLS
V0.DS(T)
DSOWC
&SER(F)
V0:DO(T)
V1:DO(F)
V1:DO(T)
DCO
V0.POW(T)
&SAF(T)
&DS(T)
DNIS
All States
V9:INOP=T
V0:DS(F)
I1
C1
V2:DS(T)
DOG
V1: DC(T)&DO(F)
V0:DOL(T)
I2
C2
DOP
To DCLS
V0: DC(T)&DO(F)
I3
C3
To DCLS
V2:DS(T)
DCC
V1:DC(F)
V0:DOL(F)
I4
DCG
C6
V1:DS(T)
I5
C5
DCDS
V0:DC(F)
I5
C5
V0.DO(T)
C6
DSCG
V1:DS(T)
Door Closed - Nodes DCLS DCDS
Door Opening - Node DOG
Door Open - States DOP, DCC
Door Closing - Nodes DCG, DSCG, DSOWC, DNIS
Door Commanded open Node DCO

Fig. 3

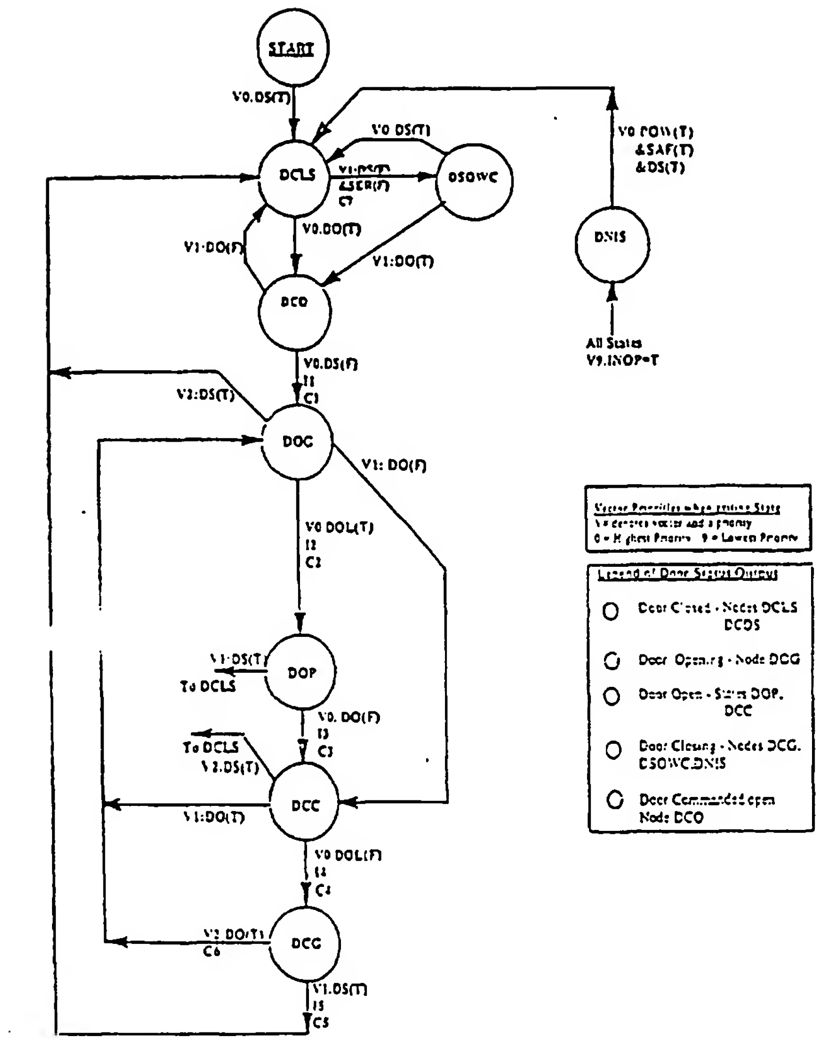
START
V0.DS(T)
DCLS
V0 DS(T)
DSOWC
V0 POW(T)
&SAF(T)
&DS(T)
DNIS
All States
V9.INOP=T
V0.DO(T)
V1:DO(T)
DCO
V0.DS(F)
DOC
V1: DO(F)
V0 DOL(T)
DOP
To DCLS
V0. DO(F)
DCC
V1:DO(T)
V0 DOL(F)
V1.DS(T)
Legend of Door Status Output
Door Commanded open Node DCO

Fig. 4

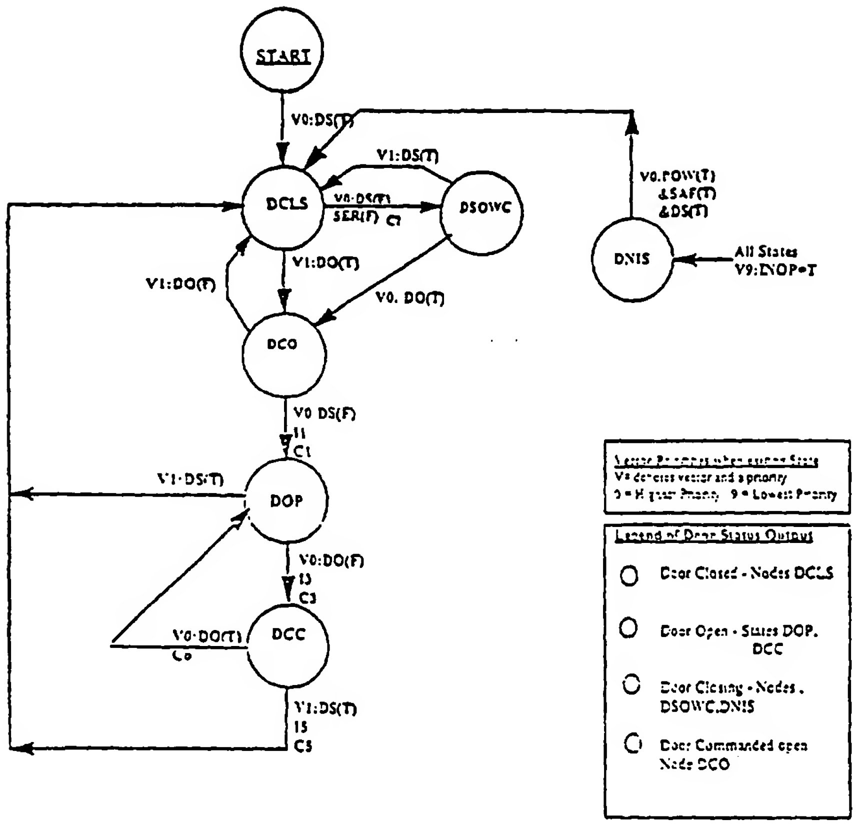
START
V0:DS(T)
DCLS
V1:DS(T)
SER(F) C7
DSOWC
V1:DO(T)
V1:DO(F)
V0. DO(T)
DCO
V0.POW(T)
&SAF(T)
&DS(T)
DNIS
All States
V9:INOP=T
V0 DS(F)
C1
DOP
V0:DO(F)
C3
DCC
V1:DS(T)
15
C5
Door Closed - Nodes DCLS
Door Open - States DOP. DCC
Door Closing - Nodes . DSOWC.DNIS
Door Commanded open Node DCO

Fig.5